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Bulacanites obtusiplicatus Gen. et Sp. Nov., a Large Lucinid Bivalve (Mollusca) from the Pliocene of Central Luzon, Philippines

Tomoki Kase[1] and Yolanda Maac Aguilar[2]

[1] Department of Geology, National Science Museum, Tokyo, 3–23–1 Hyakunin-cho, Shinjuku-ku, Tokyo, 169–0073 Japan
E-mail: kase@kahaku.go.jp
[2] Petrolab, Mines and Geosciences Bureau, North Ave., Diliman, Quezon City, Philippines
E-mail: yolagui@yahoo.com

Abstract. *Bulacanites obtusiplicatus* is described as a new genus and species of the bivalve family Lucinidae, based on the valves collected from the upper Lower Pliocene Tartaro Formation in Bulacan province, central Luzon, Philippines. This new genus has very large shells and edentulous hinge plates, and is close to *Anodontia* and *Meganodontia*, but differs in having very thick shells, anteriorly more inclined umbones, and unique radially divergent ribs in the shell surface. The sedimentary facies and associated fossils reveal that *B. obtusiplicatus* sp. nov. lived in shallow marine, intertidal to subtidal environments.

Key words: *Bulacanites obtusiplicatus*, new genus, new species, Lucinidae, Philippines, Pliocene, Tartaro Formation.

Introduction

In an effort to strengthen paleontologic research in the Mines and Geosciences Bureau, Philippines (MGB), the National Science Museum (NSM), Tokyo, Japan, and the MGB launched in 2003 a joint research program on fossil collection building and natural history studies in the Philippines. The program aims to establish standard fossil reference material in the Philippines, geared towards understanding the origin of high biodiversity in the tropical Indo-Western Pacific. Since then, the authors have been undertaking fossil collection surveys in Luzon, Cebu, Mindanao, Leyte, and Panay islands, and explored a number of younger Cenozoic fossil localities yet unstudied previously.

One of the targeted areas in this project is Bulacan province in central Luzon, where the younger Cenozoic Tartaro Formation crops out along the east-central limb of the Luzon Central Valley Basin, about 100 km north of Manila (Fig. 1). The best exposures of the Tartaro can be observed at the type section, designated in an unpublished report by Melendres and Versoza (1960), along the Madlum River in the vicinity of barrios Tartaro and Sibul, about 10 km ENE of San Miguel municipality. In the type locality, the formation unconformably overlies marine sediments of the Miocene Madlum Formation in the east, and to its west it is unconformably overlain by the non-marine Pleistocene Alat Conglomerate Member of the Guadalupe Formation (Gonzales *et al.*, 1971). Based on its sedimentary features and fossil content, the Tartaro Formation represents an intertidal and subtidal, shallow marine setting. It is slightly over 200 m thick. The formation consists of very gently dipping beds of clayey sandstone and sandy siltstone that are strongly bioturbated, or in places thinly bedded. It is highly fossiliferous throughout the succession and contains abundant mollusks and corals. Benthic foraminifers are also abundant in the matrix, and patchy coral mounds are also present mostly in the middle section of the Madlum River succession. Specimens collected from the Madlum River are not only abundant but also highly diverse and exquisitely preserved. Many

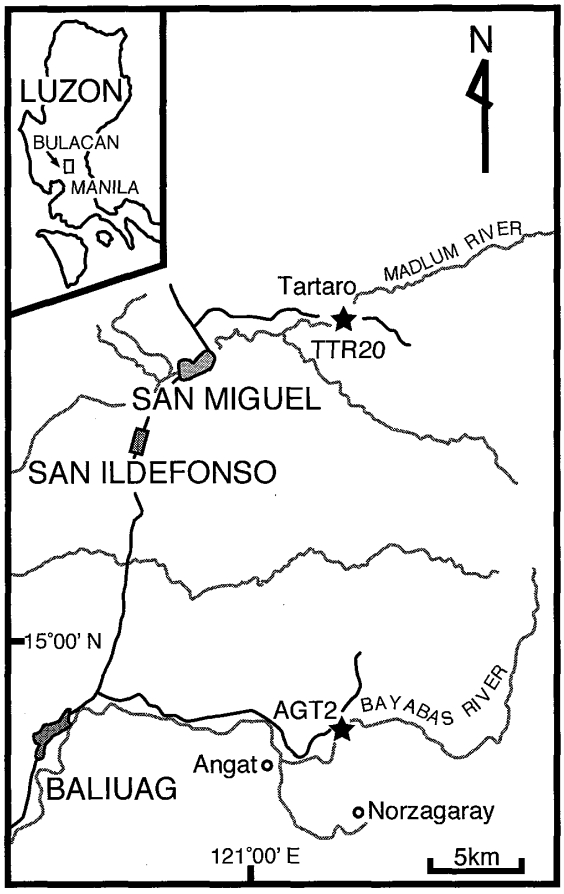

Fig. 1. Map showing the collecting localities of *Bulacanites obtusiplicatus* sp. nov. in Bulacan province, central Luzon of the Philippines.

still retain their pristine original color markings. Because of the almost flat geomorphology of Bulacan province, exposures of the Tartaro Formation are limited and widely separated. The formation also exposes in the south of the type area along the Magasawang Mangga Creek, a tributary of the Salapungan River about 10 km SSE of San Ildefonso municipality, and along the Bayabas River, about four km NE of Angat municipality. Here too, abundant and diverse molluscan fossils occasionally admixed with coral fragments have also been found.

The detailed geologic age of the Tartaro Formation has not been well understood. Gonzales *et al.* (1971) dated it as Pliocene to Pleistocene based on the benthic smaller foraminifers. In contrast, Kanno *et al.* (1982) dated a fossil-bearing horizon of the middle part of the formation in the type area as late Miocene on the basis of molluscan fossils. However, these age determinations are not reliable because benthic foraminifers and fossil mollusks are not good age indicators. Villanueva *et al.* (1995) found nannofossils indicative of late Miocene to early Pliocene from the middle part of the formation along the Madlum River. Recent preliminary nannofossil analyses by Kameo (pers. comm., 2005) showed that the Tartaro Formation along the Madlum River is within the late Early Pliocene, which is defined by the last occurrences of *Sphenolithus abies* and *Reticulofenestra pseudoumbilica*, 3.6 to 3.75 Ma (Saito, 1999).

Kanno *et al.* (1982) reported 55 species of mollusks from the Tartaro Formation. In the current project, we have been collecting fossil mollusks extensively throughout the formation at the type locality and in other newly discovered areas. As a result, more diverse fossil mollusks have been recognized, which total up to 200 species. We here initially report a remarkably large new lucinid species from the Tartaro Formation.

Fossil Localities

The specimens of the new lucinid species described in this paper were collected from locality AGT. 2 (14°57.114′N, 121°02.999′E), a riverbed of the Bayabas River in barangay Banaban, Angat municipality, Bulacan province (Fig. 1). An additional fragmentary specimen was also collected at TTR20, a riverbed of the Madlum River in barrio Tartaro of the same province. The beds exposed at locality AGT. 2 belong to the lower part of Tartaro Formation, about 15 m thick, very gently dipping, highly fossiliferous, and consists mainly of strongly bioturbated, friable, fine-grained sand and silty sandstone. The specimens were obtained from two beds in the middle and upper parts of the succession. The lower bed consists of ill-sorted, fine-grained sandstone, is not highly fossiliferous, and bears many small calcareous concretions. Two specimens collected from this bed are articulated and likely to be autochthonous in origin. Other common mollusks identified in this bed are large

gastropods such as *Melongena gigas* (Martin, 1883) and *Strombus maximus* Martin, 1882, and many articulated valves of *Placuna* (*Ephippium*) *quadriangularis* (Retzius, 1788) identified by Kanno *et al.* (1982). Two disarticulated valves are from a highly fossiliferous fine-grained sandstone bed just above an autochthonous finger-coral bed, and associated with diverse mollusks such as *Cerithium jonkeri* Martin, 1884, *C. beberkirianum*, Martin, 1884, *Strombus varinginensis* Martin, 1899, *Volema junghuhni* (Martin, 1895), *Volema* sp., several species of *Conus*, *Circe* sp., and *Dosinia* (*Bonartemis*) *stabilis* Iredale, 1929. Another common species in this bed is S*maragdia paulucciana* Gasseies, 1870, an intertidal to subtidal species known in seagrass beds in the modern tropical Pacific. Based on the associated mollusk species and corals, *Bulacanites obtusiplicatus* sp. nov. thrived in an intertidal to subtidal shallow marine environment.

Systematics

Family **Lucinidae** Fleming
Subfamily **Milthinae** Chavan
Genus ***Bulacanites*** gen. nov.

Type species. *Bulacanites obtusiplicatus* sp. nov.

Diagnosis. Shell very large, very thick, moderately inflated, equivalve, quite inequilateral, and subcircular in outline. Umbones small, situated well in front of vertical midline, markedly hooked forward, not protruded beyond ventral margin of shell. Shallow but sharp posterior sulcus present on both valves, forming shallow notch adjunct to ventral margin. Lunule absent, but depressed and extended anterior area forming pseudolunule. Sculpture of commarginal rugae, with thick diverging radial ribs. Hinge edentulous, arched, with moderately wide and flat plate. Ligament area long, arched and deeply inset into valve. Anterior adductor muscle long, slender, and curved almost in accordance with pallial line. Inner valve margin smooth.

Discussion. Based on the thick shell and the long anterior adductor scar, *Bulacanites obtusiplicatus* sp. nov. can be classified under the subfamily Milthinae Chavan, 1959. Among modern lucinids, the newly introduced genus matches well with *Anodontia* Link, 1807 and *Meganodontia* Bouchet and von Cosel, 2004 in terms of the shell size and the edentulous nature of the hinge plate. However, species categorized under these two genera are characterized by having much thinner shells, a circular shell outline, without any distinct interruption in the ventral shell margin due to the absence of radial sulci that define the escutcheon and lunule. Moreover, *Anodontia* and *Meganodontia* have a narrower hinge plate and a shorter but wider anterior adductor scar than in *Bulacanites*.

Among known fossil lucinids, only *Lucina megameris* Dall, 1901 from the upper Eocene of Jamaica was described as having an edentulous hinge and the maximum shell length about twice greater than our Tartaro specimens. Comparison of Dall's (1901a) specimens with the Tartaro specimens is difficult because they are represented by internal molds that only show the presence of a long anterior adductor scar and smooth inner ventral shell margin. Cox (1941) described a remarkably large (almost three times greater than the holotype of *B. obtusiplicatus* sp. nov.) and well preserved specimen of *L. megameris* also from the Eocene of Jamaica in the collections of the Natural History Museum, London. This specimen clearly shows a resemblance to *B. obtusiplicatus* sp. nov., based on the presence of escutcheon that is depressed from the main surface. Although information regarding the shell thickness and details of hinge and ligament areas are still poorly known, it can be presumed that *L. megameris* is closely related to *Bulacanites*. Dall (1901b) placed *L. megameris* under the subgenus *Pseudomiltha*, subsequently followed by Cox (1941) and Woodring (1982), while Bretsky (1976: 290) suggested that it be referred to the subgenus *Eomiltha*. These assignments are, however, untenable because the hinge is edentulous in *L. megameris*.

Genus *Cryptolucina* Saul *et al.*, 1996 is also a large and edentulous lucinid that originally in-

cluded *Cryptolucina megadyseides* Saul *et al.*, 1996 and *C. elassodyseides* Saul *et al.*, 1996 from the Eocene cold-seep assemblages of western Washington, USA. *Cryptolucina megadyseides* attains a shell length of about 180 mm, so far the second largest lucinid ever known. This species is represented by poorly preserved and distorted shells, but, like *B. obtusiplicatus* sp. nov., the shells are thicker (but thinner than those of *B. obtusiplicatus* sp. nov.), and have a deeply grooved ligament area that is covered by the extended shell of the postero-dorsal margin. However, this species seems to have a shell form quite different from *B. obtusiplicatus* sp. nov., in that the shells are wide, the umbones are more protruded from the dorsal margin and not so strongly prosogyrate, and the well defined escutcheon and pseudolunule are absent. *Cryptolucina elassodyseides* is smaller and longer than *C. megadyseides* and shows the presence of an elongate anterior adductor scar of lucinid type, which otherwise does not extend so long toward the vertical midline like *B. obtusiplicatus* sp. nov.

Saxolucina (*Megaximus*) *matsushitai* Matsumoto, 1971 from the lower Miocene forearc basin deposits of central Japan is also a large and edentulous lucinid that can be referred to *Cryptolucina*. The largest specimen (Matsumoto, 1971, pl. 2, fig. 1) has an equivalent shell size to *C. megadyseides*, and this species is a constituent of a chemosynthetic cold-seep community (Majima *et al.*, 2005). The type series of *S.* (*M.*) *matsushitai* appears to be an admixture of at least two species, which will necessitate future taxonomic revision based on additional material. The holotype (Matsumoto, 1971, pl. 1, fig. 1) shows an almost complete subquadrangular shell outline characteristic of *Cryptolucina*, which is definitely different from *B. obtusiplicatus* sp. nov.

Etymology. The new genus is named after Bulacan, the name of province where the bivalve-bearing formation is distributed; gender masculine.

Bulacanites obtusiplicatus sp. nov.

(Figs 2–3)

Type material. Holotype: reg. no. MGB MF0002, complete left valve, length 105.3 mm, height 106.9 mm, thickness 31.5 mm, housed in the Mines and Geosciences Bureau (MGB), Quezon City, Philippines, collected from ATG. 2, riverbed of Bayabas River in barangay Banaban, Angat municipality, 14°57.114′N, 121°02.999′E. Two paratypes in the National Science Museum, Tokyo: reg. no. NSM PM14862, fragmentary conjoined valves, length 120.5 mm, thickness in conjoined valves 57.2 mm; reg. no. NSM PM14861, complete left valve, length 95.8 mm, height 98.8 mm, thickness in single valve 30.5 mm. One paratype: reg. no. MGB MF0003, fragmentary conjoined valves, height 98.0 mm, thickness in both valves 53.5 mm, in the collection of MGB, all from the type locality.

Diagnosis. Same as genus.

Description. Shell very large for family, up to 120.5 mm long, slightly higher than wide, very thick and solid, subcircular in outline, inequilateral and equivalve, moderately inflated, with thickness/length ratio of about 0.3. Umbones small, located well anterior of vertical midline, markedly hooked anteriorly, only slightly protruding beyond dorsal margin. Shell exterior surface with dense, irregularly spaced, rugose commarginal growth lines, and with thick, round-topped, somewhat irregularly diverging radial ribs of variable prominence, numbering less than 20 at ventral margin. Ventral to antero-ventral margin broadly rounded; anterior margin slightly rostrate and set off by weakly curved radial ridge, demarcated by pseudolunule. Posterior margin with relatively large and depressed escutcheon separated from main disc by distinct posterior sulcus, junction with ventral margin forming a notch of variable prominence. Greatest dorso-ventral extension determined by rounded post-umbonal dorsal margin.

Hinge plate wide for lucinids, edentulous; anterior part broader than posterior, almost flat, and constricted just anterior of umbones due to inser-

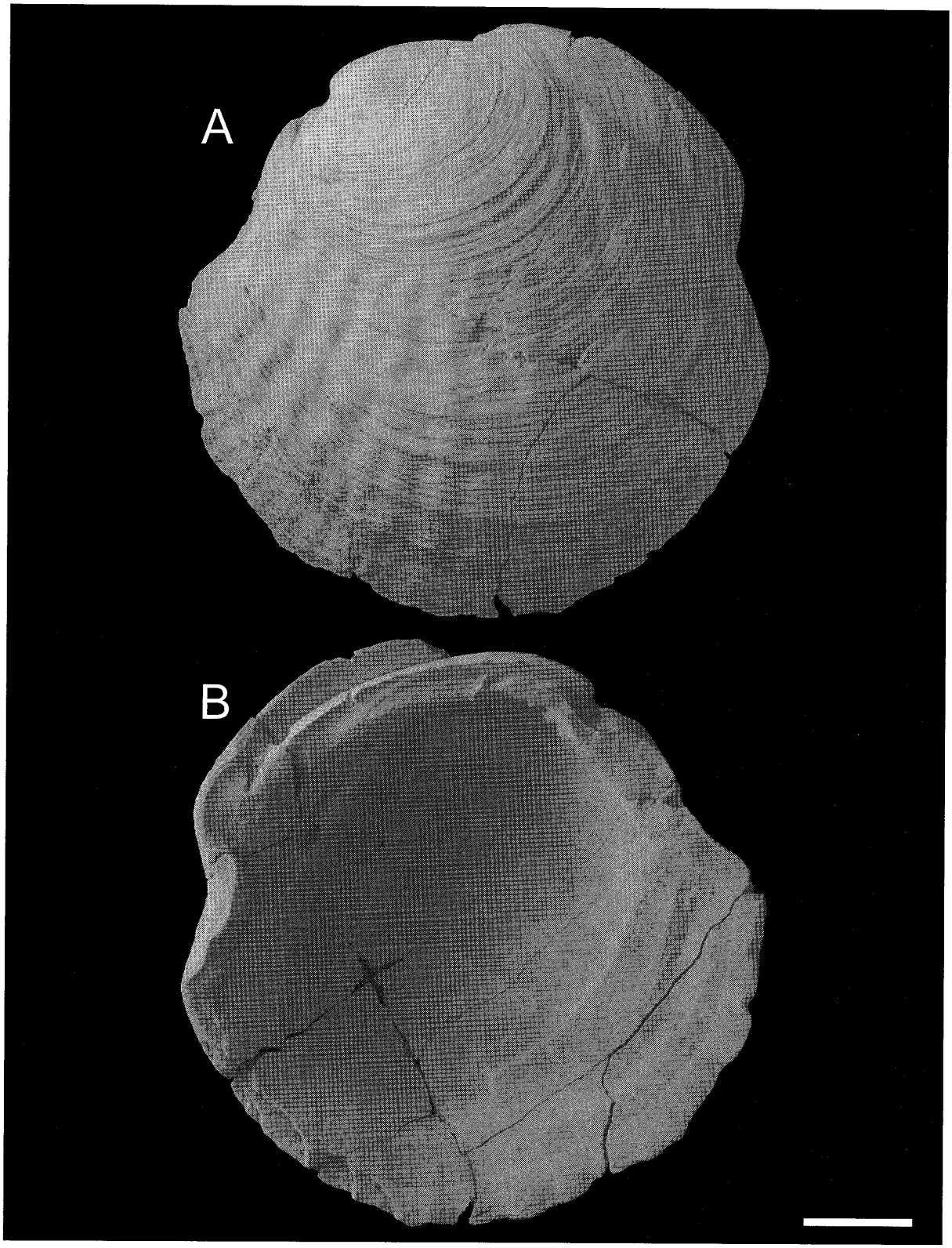

Fig. 2. Holotype of *Bulacanites obtusiplicatus* sp. nov., MGB MF0002, from a riverbed of Bayabas river, barangay Banaban, Angat municipality in Bulacan province. A, Exterior of left valve; B, interior of the same valve. Scale bar: 20 mm.

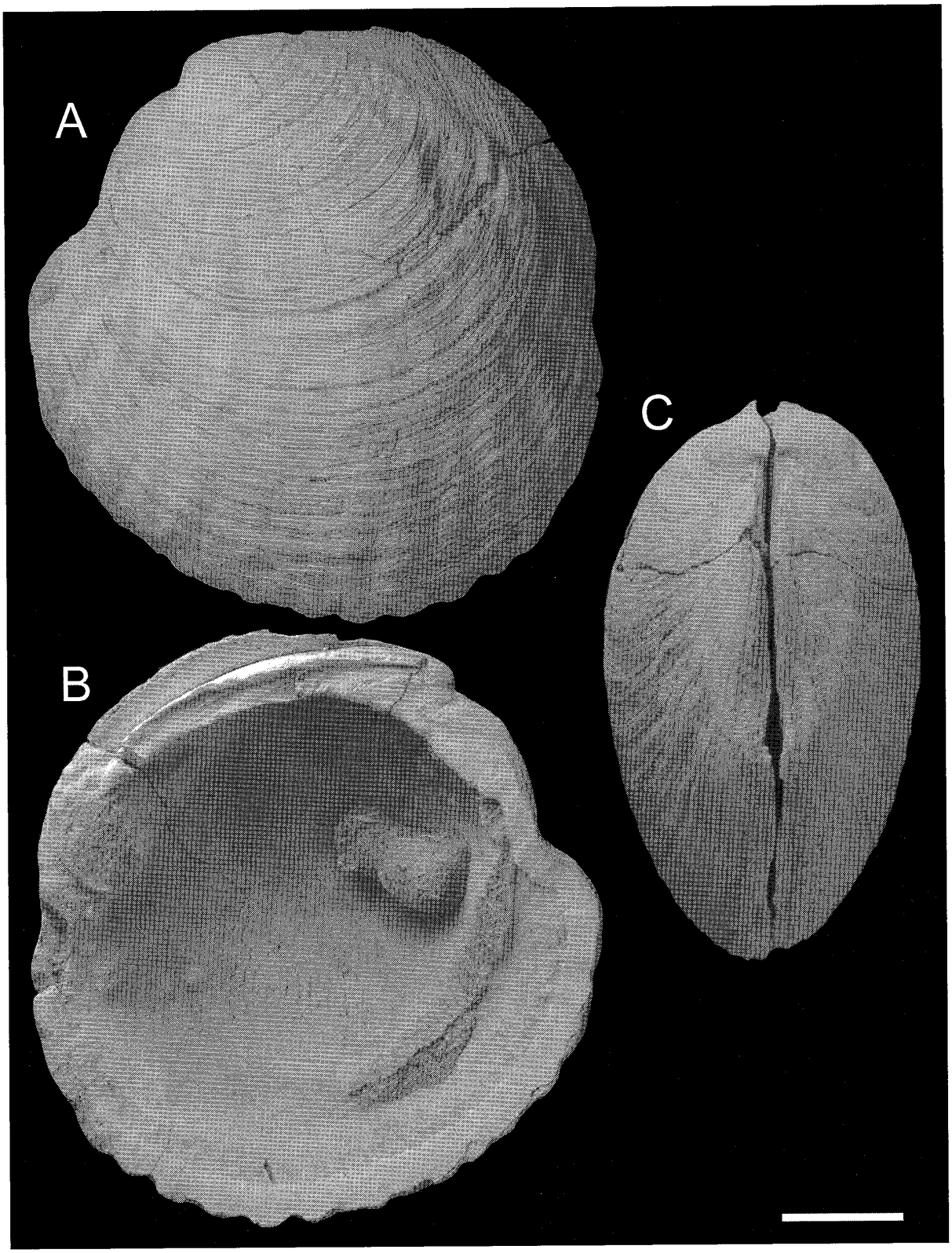

Fig. 3. Paratypes of *Bulacanites obtusiplicatus* sp. nov. from the same locality of the holotype. A & B, Exterior and interior of left valve, respectively, NSM PM14861; C, anterior view of conjoined valves, NSM PM14862. Scale bar: 20 mm.

tion of sinus; posterior part arched and variably concave medially. Ligamental area long and arched, sunken steeply and deeply into shell, with deep slit on its dorsal side; ligametal area completely covered by extension of postero-dorsal margin of escutcheon when both valves conjoined.

Inner ventral shell margin almost smooth and variably uneven, but occasionally with irregular, crest-topped radial crenulations. Inner shell surface uneven, with many, randomly distributed pits of unknown function. Anterior adductor scar very long, slender, pointed at distal end, and extending close to vertical midline, with weak, irregular radial striae. Posterior adductor scar angularly elliptical. Pallial line broad and radially striated.

Etymology. The species name refers to the obtuse ribbing on the shell surface.

Remarks. *Bulacanites obtusiplicatus* sp. nov. is quite distinct and cannot be confused with any other modern lucinids in the tropical Indo-Western Pacific. Among the living forms, only *Codakia tigerina* (Linnaeus, 1758) and *Meganodontia acetabulum* Bouchet and von Cosel, 2004 attain a shell size the same as or larger than *B. obtusiplicatus* sp. nov., but other distinct shell features separate them from our new species.

When compared with other fossil species from the Indo-Western Pacific, *Lucina maxima* Martin, 1883 is comparably larger than *B. obtusiplicatus* sp. nov. The holotype and single specimen described by Martin (1883) was collected from the upper Miocene at Junghuhn's locality O (southwestern part of the Bandong high, Rongga district, Gunung Sera or Cilanang Gap in the Nanggulan area, Java; see Hoek Ostende *et al.*, 2002). It is an internal mold of the right valve that does not show any shell characteristics except for the circular and strongly inflated shell outline. Martin (1919) illustrated an additional better-preserved specimen of this species from Solo (=Surakarta), central Java, but the shell seems to be thin according to his illustration. The authors were unable to examine the holotype and the specimen from Solo because their depositories are unknown. However, an almost complete articulated specimen (RGM6996) from the Junghuhn's locality O housed in the National Museum of Natural History Naturalis, Leiden, and two other very large specimens (the maximum shell diameter is 213 mm) from the middle Miocene of Nyalindung, west Java, illustrated and identified by Dharma (2005, p. 282) as *Anodontia* sp., seemingly match the descriptions given to *L. maxima*. If this identification is correct, *L. maxima* can be referable to *Anodontia*, which evidently differs from *B. obtusiplicatus* sp. nov.

When compared with *L. megameris*, *B. obtusiplicatus* sp. nov. is smaller and more inflated, and has many obsolete radial ribbings on the shell surface, in contrast to the smooth surface of the Jamaican species.

Lucinid bivalves have attracted much attention since many species investigated host endosymbiotic, sulphur-oxidizing bacteria, and sometimes constitute members in modern and fossil cold-seep communities (e.g., Taylor and Glover, 1997, 2000; Sara & Woodside, 2002; Kitazaki & Majima, 2003; Majima *et al.*, 2003, 2005). A unique shell feature associated with cold-seep communities is the acquisition of large size (e.g., Saul *et al.*, 1996; Bouchet & von Cosel, 2004; Majima *et al.*, 2005), and fossil examples show aggregated occurrences of such species in calcareous concretions (e.g., Majima *et al.*, 2005). *Bulacanites obtusiplicatus* sp. nov. is unusually large in shell size among lucinids from the tropical Indo-Western Pacific. However, judging from the sedimentary facies and other associated mollusks and corals, it is evidently an intertidal or subtidal shallow marine dweller during Pliocene time.

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フィリピン・ルソン島中部の鮮新世タルタロ層産ツキガイ科大型二枚貝の新属新種*Bulacanites obtusiplicatus* gen. et sp. nov.

加瀬友喜・ヨランダ・マーク・アギラー

フィリピン・ルソン島中部のブラカン地方に分布する前期鮮新世後期のタルタロ層から得られたツキガイ科二枚貝の新属新種 *Bulacanites obtusiplicatus* gen. et sp. nov. を記載した．*Bulacanites* は大型でこう歯を欠く点では *Anodontia* 属と *Meganodontia* 属に似るが，殻が厚く，殻頂部がより前方に傾き，さらに殻表面に特徴的な分岐をする放射肋をもつ点で容易に区別される．産出した地層の堆積相と随伴する他の貝化石の解析から，この二枚貝は熱帯の潮間帯あるいは潮下帯に生息していたと考えられる．